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REVIEWS

Ecological Studies in the Stockholm Cays[1]

The keynote of this interesting publication may perhaps be stated as the desirability of studying the habitats, as well as the plant associations, of a region, in order to have a real foundation for ecological conclusions. The region covered is about 2½ by 1½ miles in extent, and lies near north latitude 59° and east longitude 36°. The rocks are chiefly gneisses, with some limestone, but weathering is so slow that the soils supporting plant growth are not derived to any considerable extent from the immediately underlying rocks; instead, they are made up chiefly of materials blown or washed into protected places. Comparison of post-glacial geologic records and old maps with the present-day geography indicates that the land has been gradually rising with reference to mean sea level, so that the area suitable for occupation by vegetation is continually increasing.

The first subject of inquiry concerns the relation between land area and number of species present. Comparison is made between a pure plant association, the *Sesleria*-meadow, certain alpine regions studied by Jaccard, and two groups of cays, those of Bullerö and Munkö. In all of these cases the number of species is found to be directly proportional to the area concerned in each count, the relative abundance increasing in the regions studied in the order named. It is concluded that species are rather regularly distributed over at least a fairly large portion of the earth's surface.

The behavior of weeds in various places on the cays where more or less cultivation has been attempted is described statistically, and the failure of most of them to persist long after farms are abandoned is pointed out. Tabulations are then presented of the species of plants found in the region, which number nearly 500. They are classed as: Widely distributed species (*a*) in the strict sense, (*b*) rarely met with, (*c*) of the inner zones, and (*d*) of the outer zones; species limited to (*a*) the inner and (*b*) the outer zones. About 50 of these species have peculiar ranges, or are here at a limit of range; and southern, southwestern, southeastern, etc., plants are noted.

The recent geological age and continual enlargement of the region indicate that plants are actively migrating into it, and the means of introduction are considered. Most of the species have come from the adjoining mainland. Large quantities of seeds were found to be carried frozen in ice from the mainland to cays, and from one of them to another. Distribution by wind plays but little part in this region. An exceptional abundance of plants with fleshy fruits shows that birds are important in this connection, however, and the species of southern affinities are believed to have been brought in largely by their aid. These species can not be relicts from some earlier warm period, as has been suggested, because the average observed rise of ½ meter per century indicates that the cays are not more than perhaps 5,000 years old. The fact that here as elsewhere species of southern origin range further north along coast lines than they do inland is connected with routes of bird migration being largely along coasts.

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[1] "Öcologische Studien in den Stockholmer Schären," von O. Arrhenius. Privately published; Tryckeriaktiebolaget Svea, Stockholm, Sweden, 1920. [In German.]

The Swedish word Skär (pronounced shaer; German equivalent Schär) refers to tiny islets, sand-bars, rock-ledges, etc. The best translation seems to the reviewer to be the Scottish word "cay." Alternatives would be quay and key, but these have additional meanings and might be misleading.

The plant associations or societies of the region are treated statistically, the syn-ecological method of measurement along lines with units a meter in length having been applied in collecting data. It is shown that existing associations are in a state of comparatively rapid change, and the general course of development is brought out by charts and descriptions. The gradual formation of covers of vegetation on bare rocks and sands is fully treated. [An abbreviation for association used in this chapter and elsewhere, " Ass " (often without a period), looks strange to English readers.]

The chapter of greatest interest (at least to the reviewer) is No. 4, on the " Standort " or habitat. Realizing the extreme importance of the chemical, as well as the physical, features in determining what plants will grow in a given place, the author decided to make determinations in the soils of potassium, calcium, phosphoric acid, and of nitrogen in three forms, total, ammoniacal and nitrate. In addition, the ash and the potassium carbonate content of the vegetation was determined. The physical investigation comprised the determination of the water content, the mean size of grain, and the volume-weight of the soil samples; also "of the for life in the soil most important but as yet little considered factor, namely the H-content of the soil." It is explained that by the term H-content is meant the hydrogen-ion concentration; actually the hydrogen-ion potentials are given. [The reviewer would be inclined to classify reaction as a chemical rather than a physical factor.]

It thus appears that Arrhenius and the reviewer hit upon the idea of applying determination of soil reaction (acidity, alkalinity) to the study of the distribution of native plants independently. The one has considered associations, the other individual species; but the results are to a certain extent comparable, as will herein be pointed out. The reviewer will take the liberty of adding, in parentheses, to the potential values given by Arrhenius the corresponding " specific acidities " or " specific alkalinities," since they are so much more readily comprehensible. For example, an *Arctostaphylos* association is recorded as having " $H=4.8$ " and a *Calluna* ass.

"H 4.6," but it is difficult to gain a conception of the relative acidities represented from these figures. When translated into the specific acidity form, however, they yield 159 and 251, respectively, and it can then be seen at a glance that the *Calluna* soil is over 1½ times as acid as the *Arctostaphylos* soil.

Soil samples were obtained by digging down to the levels in which the plants were rooted, noting the sequence of layers passed through, and collecting about three 150 cc. glass jars full of each soil. The acidity ("H") was determined immediately after sampling. The colorimetric method is sufficiently precise for such investigations, for the H-exponent becomes decidedly greater (*i.e.*, the acidity decreases) the deeper the soil is penetrated. As the change approximates 0.1 in " H " (from 0.25 to 2.1 in specific acidity) per centimeter, it is not only unnecessary, but actually incorrect, to state " H " with greater exactness than 0.1 (specific acidity with greater exactness than 1 unit). The greatest variation observed in a single sample of soil was 0.2 in " H " (2 or 3 specific acidity units).

The method of determining soil reaction used was as follows: 10 grams of the soil in its naturally moist condition was shaken with 50 cc. of water and allowed to settle for several hours. The liquid was then filtered, and samples taken for trial with indicators, the Clark-Lubs series of these being employed. To avoid the disturbing effect of coloring matter extracted from the soils a comparator was used, comparison being made against buffer mixtures differing by 0.1 in " H " value, to which the appropriate indicators were added. Dilution was found to have no essential effect on the results.

Another physical factor which it was desired to determine was size of grain of soils. Many different methods have been suggested and are in use for this purpose, but the results are not comparable from one to another. The method which seems open to the least objection is that of A. Mitscherlich, in which the soil is allowed to stand in a moist atmosphere until it ceases to absorb more water, whereupon it is weighed. By then drying and again weighing, the weights of both soil and water can be obtained. The best measure of the surface of the soil particles is the hygroscopicity in percent of dry substance.

The methods of analysis of all the chemical constituents listed above are given in the paper. It need only be stated in this review that because of the uncertain significance of the various methods of ascertaining the conditions of substances (*i.e.*, water-soluble, citric acid-soluble, etc.) only the total content of each was determined. In order that they may be comparable, all analytical results are referred to the dry weight.

Just as temperature has been found to be of great influence on the life and development of plants and their societies, so has the "H-content" (*i.e.*, reaction) of the nutritive medium been found to produce analogous effects. As the data on the higher plants are relatively meager, the author's assistant,

R. M. Hixon, carried out some experiments along this line. It was found that as far as germination and early growth were concerned the plants studied seemed to be relatively indifferent toward the reaction, and between "H" 3 and 9 (specific acidity 10,000 and specific alkalinity 100) these processes take place normally. However, the plant roots were found to be able to change the reaction of the medium. Rye brought solutions of the above initial extreme reactions alike to "H" 5.8 (specific acidity 16), peas to 4.5 (sp. ac. 316) and corn to 6.5 (sp. ac. 3).

The range of acidity observed in the various plant associations, some 80 in number, is tabulated. It was found [as is also the reviewer's experience] that a given plant or group of plants is likely to show a range of 0.5 of an "H" unit (= sp. ac. 3 +). The number of associations found in the cays to occupy each such range is as follows:

"H" value	8.0–7.5	7.5–7.0	......	7.0–6.5	6.5–6.0
Sp. alk.	10–3	3–1	Sp. ac.	1–3	3–10
Number	3	7	......	30	22

"H" value	6.0–5.5	5.5–5.0	5.0–4.5	4.5–4.0
Sp. ac.	10–30	30–100	100–300	300–1000
Number	8	4	5	1

In words, native plants in general favor a reaction lying slightly to the acid side of the neutral point, and there are relatively few of them found in soils of a greater specific alkalinity than 3 or a greater specific acidity than 30. [This accords entirely with the reviewer's experience in eastern North America.]

The plant associations found on the alkaline side of neutrality comprise the reed and strand formations, the latter, however, extending slightly over to the acid side. Practically all of the associations rich in herbs lie between "H" 7 and 6 (sp. ac. 1 and 10). Those of lower "H" (*i.e.*, higher acidity) are the heath-formations, although a few of these may also show less acidity. [It has been particularly interesting to the reviewer to compare the results obtained on plant species which are common to the Stockholm cay region and eastern North America, and which have been studied as to soil reaction. Among these may be mentioned the ferns *Polypodium vulgare, Asplenium Trichomanes, A. Ruta-muraria, Woodsia ilvensis,* and *Ophioglossum vulgatum,* the "cow-slip," *Caltha palustris,* and the ericaceous plants *Pyrola secunda* and *Arctostaphylos Uva-ursi.* In all of these cases essentially identical ranges of reaction have been found in the two regions. In a few cases where a plant is represented by different varieties on the two continents the soil reactions may either be the same, as proves to be the case in *Pyrola rotundifolia,* or distinctly different, as in *Pteridium aquilinum* and *Vaccinium Vitis-idaeus.*]

Arrhenius finds that it seems as if the plant-associations themselves develop the kind of sub-stratum in which they can grow the best, and the mineral make-up of the original soil is subordinate in importance. Naturally, external factors favor the starting of certain plant-associations and hinder others; but when a plant society has once overcome the initial difficulties, and has obtained a humus-containing layer, then the other factors cease to be dominant. In the different reactions of soils may well be found one of the causes which most strongly influence the course of soil formation. Three types of humus-soil can be distinguished by the plant-associations which occupy them—the herb, the grass and the heath types. Now, these types correspond exactly to groups based on soil reaction; can this be entirely accidental? The colloidal nature of humus suggests that it is not, but that the acidity of the soils acts upon the humus to change its character and render its nutritive constituents more (or less) available to the particular plants present. It is noteworthy, further, that mineral soils are in general less acid than the overlying humus, and the boundary between them may be rather sharp. Also that plant formations of youthful nature do not change the acidity markedly until they have developed an extensive humus layer.

The reaction influences not only soil or humus development, but also most of the processes which take place in the soil. As shown by a chart, the nitrogen content, as well as its form, is closely related to the reaction. Nitrate nitrogen is at a maximum slightly on the acid side of the neutral point, ammoniacal nitrogen between "H" 5.7 to 5.2 (specific acidity 20 to 60); total nitrogen shows a slight maximum at 5.2 (sp. ac. 60). Some interesting distribution relations are also brought out; in general the plant foods are concentrated in the lower part of the humus layer. A summary, bibliography and table of soil analyses complete the paper.

From the foregoing review it will be seen that Dr. Arrhenius has shown marked progressiveness in his approach to ecological problems. A few minor criticisms of his work may perhaps be suggested here. Had the work been done in a region where limestone was more prominently developed, it is probable that his conclusions as to the ability of plant-associations to develop their own sub-stratum in spite of the rocks beneath would have been somewhat modified, for this rock is usually quite effective in preventing the development of the heath type of vegetation over it. It seems likely, moreover, that lime and other plant foods may at times be so tightly locked up in a soil that the plants can not get at them, so that it is not safe to draw too sweeping inferences from the total content of these substances, although admittedly the methods in use for determining "available" plant foods need radical revision. Finally, bacteriological and mycological cultures of the soils studied might have thrown some interesting light on how soils best suited to their needs develop beneath certain plant-associations. But Arrhenius has done so much worth while that it is not reasonable to criticize him for not covering everything. On the whole his paper represents an extremely valuable contribution to plant ecology.

EDGAR T. WHERRY

HUMAN ECOLOGY[1]

School courses in elementary geography have been restricted mainly to political aspects. Now and then a deviation from the usual routine has occurred. In one instance the course of study began with the geography of the Holy Land. The reason for the departure from the normal was profound: civilization began with Jesus of Nazareth and he was born in Palestine (sic). This course of study was prepared for a large city and, for a time, was in use.

Physical geography, a knowledge of which is most necessary to the broader understanding of human history, is well nigh out of school courses altogether. Usually it is an optional study; and if it counts no credits in a prescribed course, few pupils take it.

So far as systematic work is concerned, in the greater number of schools the study of geography is finished in the sixth year. Of the various studies best calculated to develop breadth of character and to impart useful knowledge, geography, history, and literature have the foremost place: and the first named of these studies is finished when the pupil is about eleven years of age!

School text books are made to fit school courses. Most of them are good, but the quality of the text counts but little. If the text does not fit the course, it is of but little use. If it fits the course of study, a text book is likely to be adopted—good, bad or indifferent.

Huntington and Cushing's Principles of Human Geography is unique. It doesn't come within gunshot of any course of study within the United States; it is in the wildest and widest violation of all of them. A pupil might memorize it from *a* to *izzard* and the contents would get him about as near to the Regents' examination as a study of Adam's off ox.

One incidental feature of the book is worth noticing. It is geography—the genuine stuff—from cover to cover. It is the study, not of calico colors embordered with broken black lines, but of environment and the man. The text explains how and why the industries and employments of peoples are largely controlled by conditions that are strictly geographic; and how and why man within certain natural limits may overcome his environment. Two animals only are able to cross a stretch of desert two days of travel in width—the man and the camel. The camel is built that way; the man

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[1] Principles of Human Geography, by Ellsworth Huntington and Sumner W. Cushing. John Wiley and Sons, Inc. New York and London. 6x9 in., pp. xiv, 430; 118 illustrations, including half tones, maps and diagrams. 1921.